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Soviet Wing-in-Ground-Effect Vehicles: A New Player in Naval Surface Warfare

An Intelligence Assessment

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Soviet Wing-in-Ground-Effect Vehicles: A New Player in Naval Surface Warfare

An Intelligence Assessment

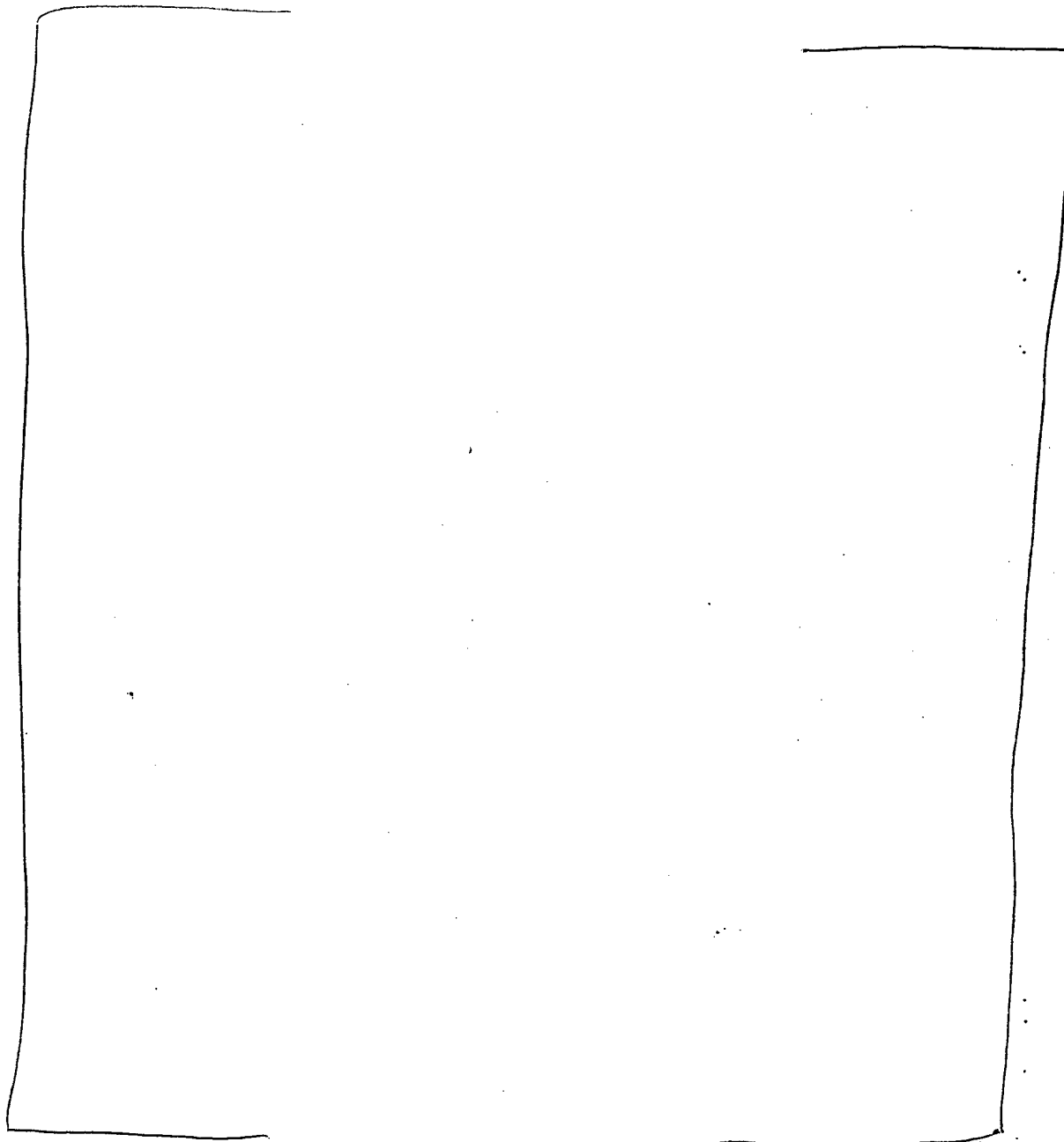
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Wing-in-ground-effect vehicles, or WIGs, are hybrid naval vehicles that combine features of surface ships and aircraft. Soviet WIGs are built by the Ministry of Shipbuilding Industry, yet they look like airplanes and cruise above the surface of the water. The Soviets are developing two classes of WIGs - the Orlon and the Utku - for which there are no US counterparts.

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Soviet Wing-in-Ground-Effect Vehicles: A New Player in Naval Surface Warfare

Key Judgments

*Information available
as of 1 September 1988
was used in this report.*

We believe that the Soviet wing-in-ground-effect vehicle (or WIG) program, which began in the early 1960s, will culminate in deployment in the early-to-mid-1990s. WIGs will add a new dimension to naval surface warfare when they become operational. They are designed to fly at speeds of 200 to 250 knots about 5 to 10 meters above the water's surface (the ground-effect zone)

Two classes of WIGs are being developed for the Soviet Navy:

- The Orlan-class WIG is an amphibious assault vehicle for the Soviet naval infantry. It can carry two armored personnel carriers and 100 fully equipped combat soldiers across seas and along coastal and inland waterways. The Orlan is about the size of a US B-52 bomber and flies at about 200 knots. The Soviets have three Orlan-class WIGs.
- The Utkha-class WIG is a tactical strike and coastal defense vehicle for the Soviet Navy. It carries six supersonic SS-N-22 antiship cruise missiles. The Utkha can engage enemy ships out to its radar horizon (about 35 kilometers) but can fire the SS-N-22 out to the missile's 100-kilometer range with over-the-horizon targeting data. The Utkha is larger than a US Boeing 747 jet airplane and flies at about 250 knots. One Utkha has been built

The Orlan has sufficient range to reach any beach in the Baltic Sea, Black Sea, or the Sea of Japan from the USSR. However, the Orlan's relatively small carrying capacity will require it to operate in squadrons of six or more to be effective. We believe that an Utkha strike force or coastal defense force would give the Soviets a quick-reaction capability against surface combatants. However, unless the Utkha can pop up out of ground effect to extend its radar horizon, it will require external sources of targeting information

The Orlan and the Utkha will be vulnerable to attack from enemy aircraft. Because WIGs fly close to the water, they cannot maneuver quickly, and their engines are susceptible to seawater ingestion and foreign-object damage. The effectiveness of the WIGs may also be degraded by inclement weather, although ~~we~~ suggest that they can take off and land in waves as high as 5 meters

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As yet, we have seen no evidence that any Soviet shipyard is prepared to serially produce the Orlan- or Utko-class WIG. Because WIGs are products of the Soviet Ministry of Shipbuilding Industry, they will be built at a shipyard and not at an airframe plant, as one might expect. []

We believe that the Soviets intend to deploy the Orlan and the Utko to the Baltic, Northern, Pacific, and Black Sea Fleets. Two or three Utkos and five or so Orlans could be assigned to each fleet by the late 1990s. If higher numbers of WIGs are to be deployed, the Soviets will probably need a production facility larger than the one they use now

In addition to the Orlan's amphibious operations and the Utko's tactical strike and coastal defense missions, Soviet WIGs could be configured to perform other missions. These include antisubmarine warfare, minelaying, and search and rescue

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Soviet Wing-in-Ground-Effect Vehicles: A New Player in Naval Surface Warfare

Introduction

Early in this century, flight researchers discovered that the induced drag of a wing operating near the ground is reduced, resulting in an increased lift-to-drag ratio (see inset). Designers took advantage of this wing-in-ground effect to build hybrid vehicles that combine the inherent advantages of surface ships and aircraft. Wing-in-ground-effect vehicles, or WIGs, are capable of flying at 200 to 250 knots just above the surface of the water.

Soviet WIGs are the result of a research program started in the early 1960s. The research produced a wide variety of WIG designs and models ranging in size from about 100 kilograms to 400 metric tons. The largest WIG built by the Soviets []

and nicknamed the Caspian Sea Monster in the West. []

[] Two classes of WIGs, designated by NATO as the Orlan-class [] and Utka-class [], are currently being developed for the Soviet Navy (see figure 2).

The Orlan-Class WIG

Characteristics

The first fully assembled Orlan was [] in 1974 at a special research facility in Kaspysk, on the Caspian Sea. The Orlan is approximately the size of a US B-52 bomber (see figure 3). It [] weighs approximately 140 metric tons (see table 1). The Soviets have three Orlans.

The Orlan is an amphibious assault vehicle for the Soviet naval infantry. The crew compartment and the forward engines are contained in the nose section, which is hinged on the starboard side. []

Table 1
Orlan-Class WIG: Characteristics and Estimated Performance

Overall length (meters)	[]
Wingspan (meters)	[]
Wing surface area (square meters)	[]
Tailspan (meters)	[]
Tail surface area (square meters)	[]
Weight (metric tons)	140 (approx)
Payload (metric tons)	34
Cruising speed (knots)	200
Radius of operation (nautical miles)	700 to 900

[] The side-hinged nose section allows easy on- and off-loading of equipment, but it could cause clearance problems if the nose were opened on an irregular landing surface. Our analysis suggests that the Orlan is able to carry 100 fully equipped troops and two armored personnel carriers or 200 fully equipped troops.

Performance

The Orlan is powered by three engines. Two turbofan engines are an integral part of the nose structure, and a contrarotating turboprop is mounted on top of the tail. The nose engines not only provide axial thrust but also create a high-pressure region under the wing to provide lift—the power-augmented-ram phenomenon (see inset).

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[] Orlan indicate that, [] it acts much like a seaplane (see figure 4). As more exhaust is forced under the wings and held stagnant by the endplates and trailing-edge flaps, the vehicle lifts partially out of the water. This reduces the drag on the hull of the craft, and its speed increases. The hull of the vehicle probably breaks contact with the surface [] the Orlan transitions into wing-in-ground-effect flight. When this happens, the pilot will probably be able to cut back on power, or possibly even shut down the two turboprops in the nose, and maintain wing-in-ground-effect flight [] with the tail-mounted turboprop. The Orlan probably cannot fly out of ground effect like an airplane on the turboprop engine alone, but it probably can with the nose-mounted turboprop engines engaged.

[] Because WIGs fly close to the surface, they cannot maneuver quickly. To turn, they must either pop up out of ground effect to bank or make a wide, deliberate turn []

Mission

The Orlan is well suited for both strategic and tactical missions.¹ In strategic operations, it can deliver men and equipment in a flanking maneuver 10 times faster

¹ Strategically, Soviet doctrine views amphibious assault as a flanking maneuver with the intention of driving into the enemy rear area and quickly joining up with the Soviet forces attacking the main front. Tactically, Soviet doctrine stresses surprise as essential to the success of the operation.

Wing-in-Ground Effect and Power-Augmented-Ram Phenomenon

In the early 1900s, researchers discovered that a wing operating near the ground exhibits a reduction in induced drag, which increases its lift-to-drag ratio. This wing-in-ground effect has been studied for several decades because it complicates the takeoff and landing of low-wing aircraft. The wing-in-ground effect was initially seen as little more than a nuisance, and efforts to understand it were stimulated only by a desire to eliminate it.

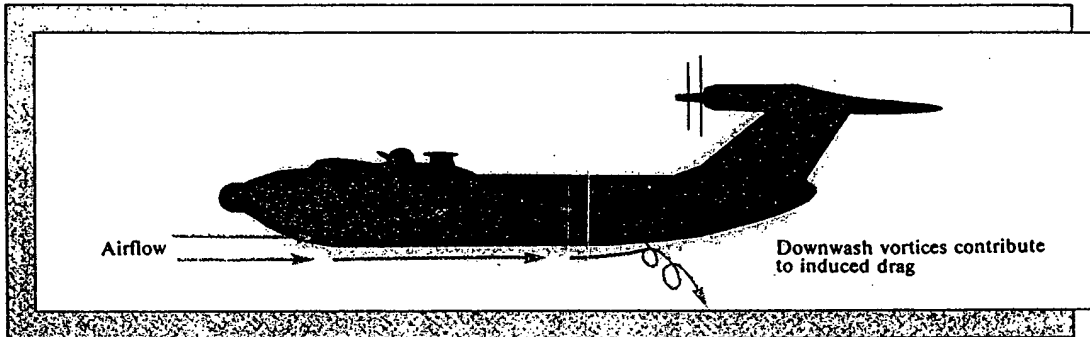
In 1922 a classic study on the wing-in-ground effect correctly proposed that it was an increase in the overall lift-to-drag ratio caused by a reduction in the induced drag of a wing as it neared the ground (see figure). Induced drag is caused by downwash vortices coming off the trailing edge of the wing. By flying close to the surface, the amount of downwash is reduced. The closer the wing is to the surface, the greater the reduction in induced drag. The distance from the ground is normally given in wing chord lengths (the distance from the leading edge of the wing to the trailing edge). Wing-in-ground-effect flight occurs when the wing is approximately one-half chord length above the surface. The ocean represents the largest, flattest surface on earth, but it still contains surface irregularities. Therefore, to achieve the stability and performance required for open-ocean operation, very large vehicles are needed to maintain a reasonable flying altitude above the highest wave.

During the 1960s, a phenomenon was discovered that significantly enhanced the performance of WIGs. The power-augmented-ram phenomenon results when the exhaust from forward-mounted propulsion engines is directed under the wings, where it is held nearly stagnant by endplates and a trailing-edge flap. At low speeds, a static pressure rise occurs under the wings and lifts the vehicle out of the water. Hydrodynamic drag at takeoff is therefore drastically reduced, allowing operation with lower thrust engines. The power-augmented-ram phenomenon reduces water impact on the wings during landing, permitting reduced wing structural weight and heavier vehicles

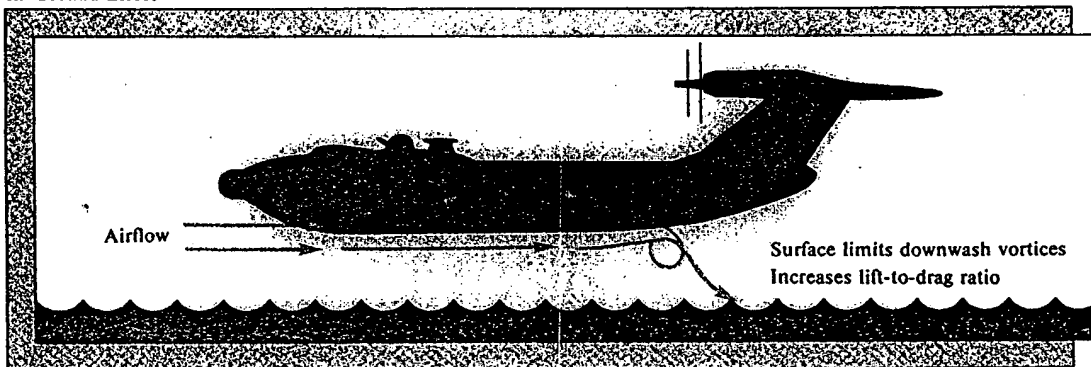
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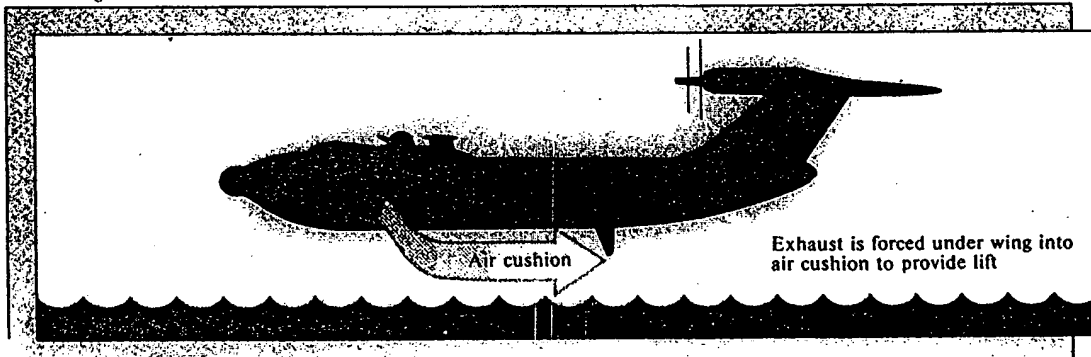
Out-of-Ground Effect



In-Ground Effect



Power-Augmented-Ram Phenomenon



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Figure 2.

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Figure 3
Size Comparison of Soviet Orlan-Class
WIG and US B-52 Bomber

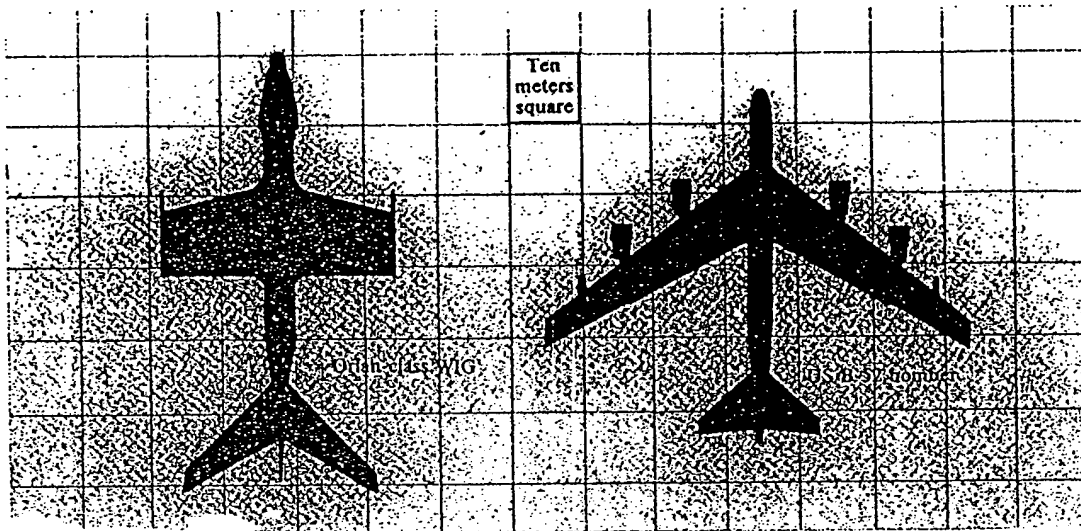
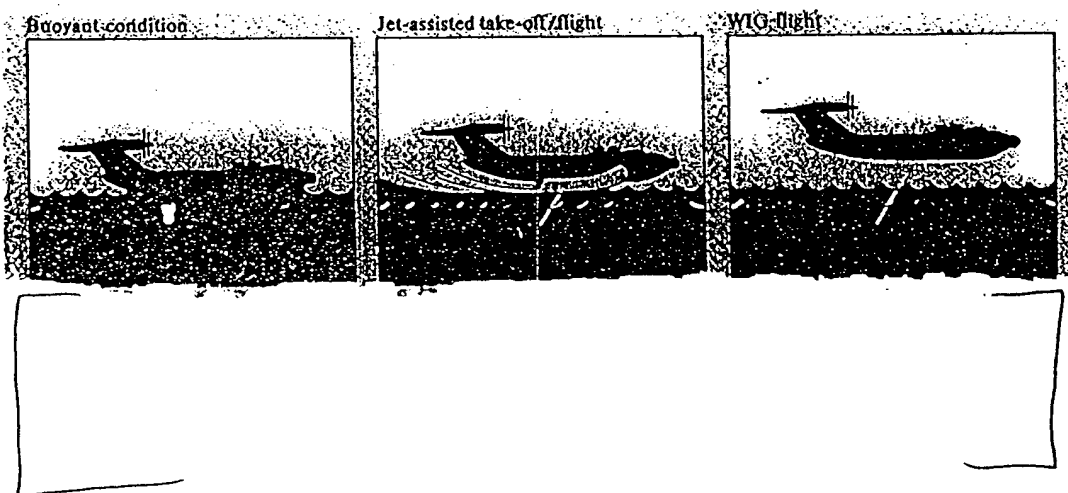


Figure 4
Flight Profile of a WIG



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Figure 5.

than conventional Soviet landing ships. In tactical operations, the Orlan offers an extra element of surprise and speed. Figure 6 shows the following areas where the Orlan-class WIG could possibly operate:

- An attack behind the NATO frontline into West Germany or Denmark.
- Securing airfields in northern Norway.
- Landings across the Black Sea, the Caspian Sea, or the Sea of Japan.

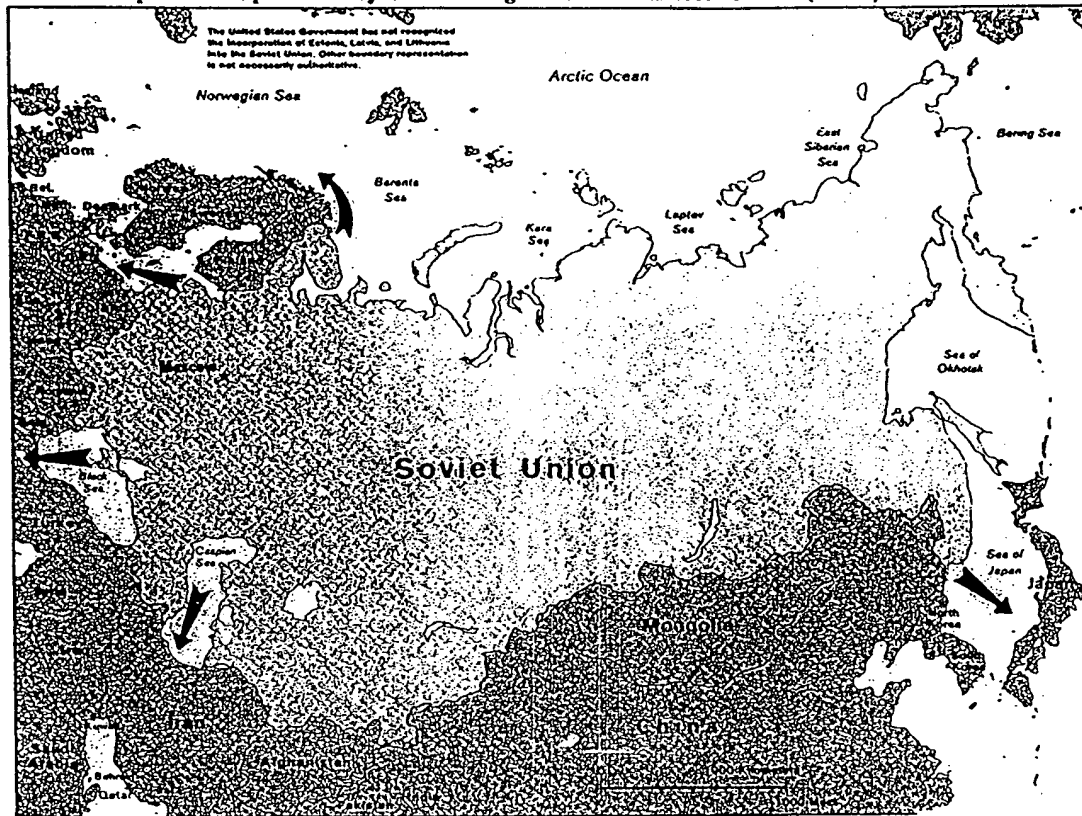
The Orlan has sufficient range to reach any beach in the Baltic Sea, the Black Sea, or the Sea of Japan from the USSR. The Orlan can also reach areas in northern Norway and Iceland from the Kola Peninsula, but it will probably require a refueling-at-sea capability in order to return to base.

The Orlan will not be used to attack heavily defended beaches because it has less armor protection than conventional landing and assault ships. Its higher speed, however, will allow it to operate in smaller assaults on lightly defended or already secured beaches. The Orlan's relatively small capacity to carry equipment will also require it to operate in squadrons of six or more, or as an element of a large amphibious assault, to be effective.

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Figure 6
Possible Amphibious Operations by Soviet Wing-In-Ground-Effect Vehicles (WIGs)



The Utko-Class WIG

Characteristics

The Utko was first seen in 1986 at the special research facility in Kaspiysk, on the Caspian Sea. The Utko is the only one has been built. Unlike the Orlan, the tail of the Utko is a major lifting surface. Our analysis indicates that the vehicle weighs approximately 400 metric tons (see table 2).

The Utko is a tactical strike and coastal defense vehicle. It carries six SS-N-22 antiship cruise missiles mounted on top of its fuselage in three sets of launch tubes (see table 3).

We do not know if the missiles can be launched from the Utko while it is flying in ground effect. If missile launches occur while Utko is dead in the water or

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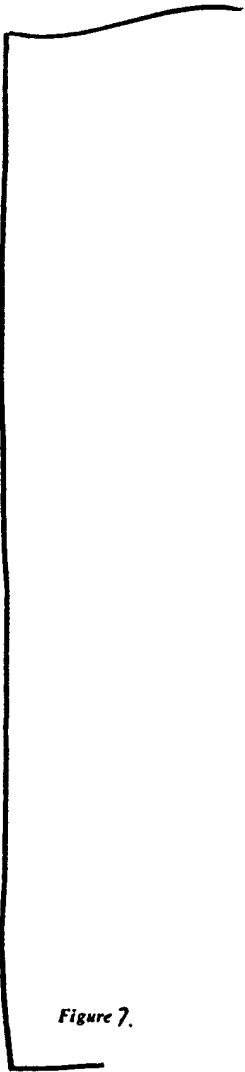
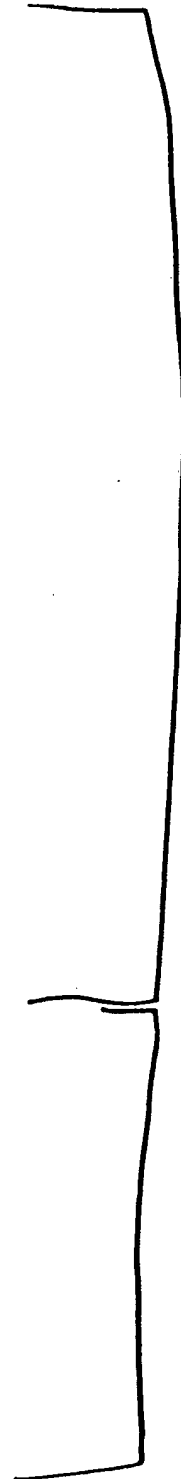
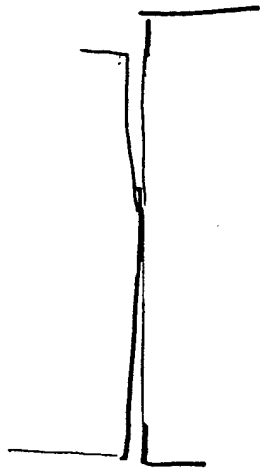


Figure 7.



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Table 2
Utka-Class WIG: Characteristics and
Estimated Performance

Overall length (meters)	
Wingspan (meters)	
Wing surface area (square meters)	
Tailspan (meters)	
Tail surface area (square meters)	
Weight (metric tons)	400 (approx)
Payload (metric tons)	
Cruising speed (knots)	250
Radius of operation (nautical miles)	800 to 1,000

Table 3
SS-N-22 Antiship Cruise Missile
Characteristics

Dimensions (meters)	
Length	
Diameter	
Weight (kg)	≈ 3,500
Propulsion	
Booster	Solid rocket
Sustainer	Liquid-fueled ramjet
Warhead	
Type	High explosive or nuclear
Weight (kg)	300 to 400
Speed (Mach)	2.3
Cruise altitude (meters)	≈ 20
Range (km)	
Minimum	10
Estimated maximum	≈ 110
Guidance system	Preprogramed autopilot probably with active radar homing
Targeting system	Direct targeting using surface search radar and remote targeting using tactical tracking data from other vehicles with a system similar to Band Stand

Performance

While not requiring "high" technology, WIGs certainly require a new integration of technologies. They are more complex than many ships or conventional aircraft, and they require extensive maintenance to keep them seaworthy. Turbofan engines on WIGs are especially maintenance intensive. Their performance degrades significantly in a salt-air environment without proper maintenance.

the Utka will be able to operate in rough seas and can probably take off and land in a "sea state 5" condition

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Figure 8.

Higher seas and inclement weather, however, will probably cause the engines to ingest seawater, limiting the vehicle's operation

Mission

Our analysis suggests that an Utkas strike force or coastal defense force would be capable of launching a surprise attack against surface combatants. A single Utkas could approach a target to just beyond the target's radar search range and then pass its targeting data, to other Utkas located beyond the target's radar horizon. These Utkas could make the final strike. This

hand-over capability would also permit over-the-horizon targeting for SS-N-22 antiship missile attacks with minimum risk to the action group

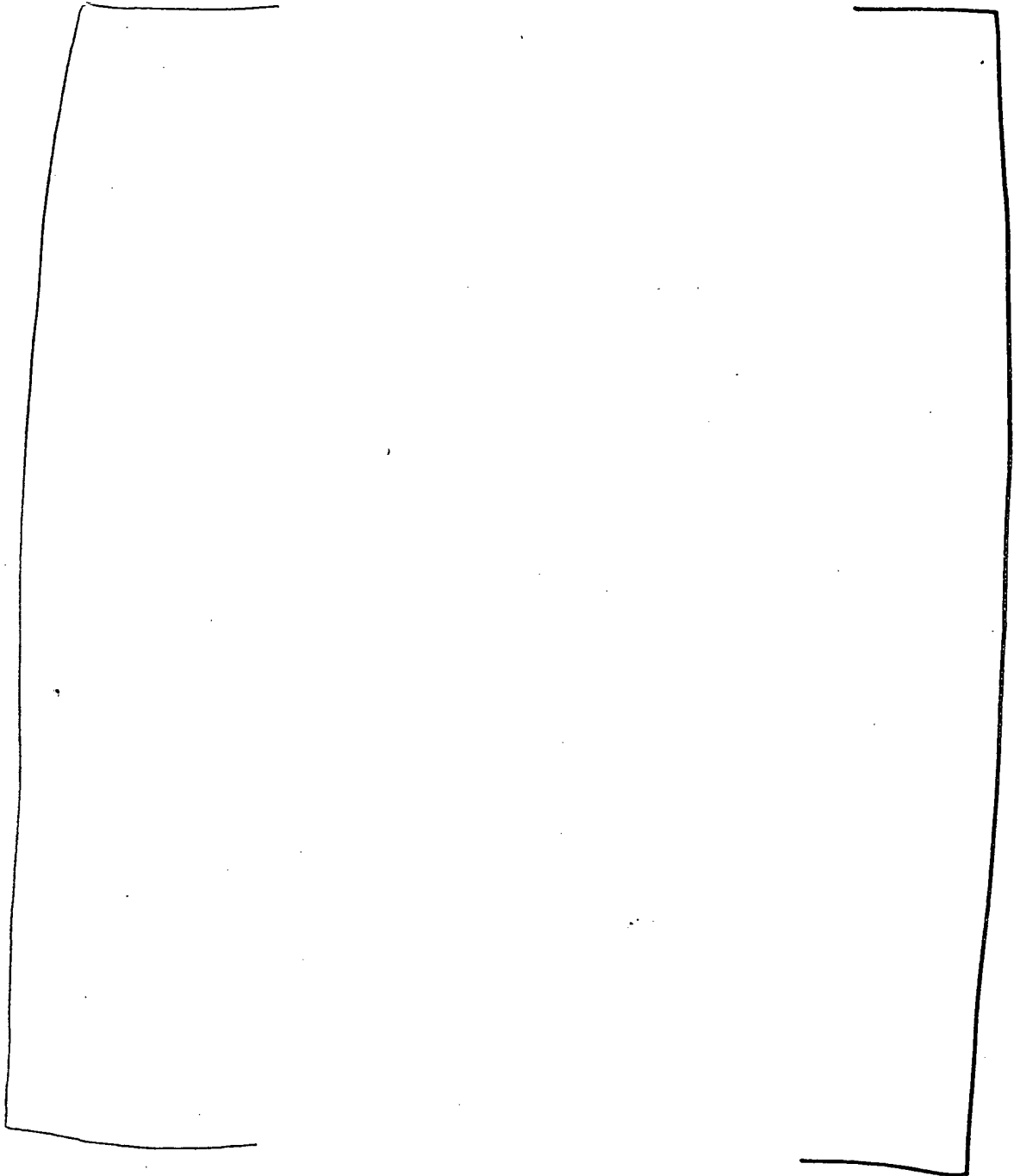
Flying at its expected cruise altitude of 5 to 10 meters above the water's surface, the Utkas' radar

could probably detect a ship-sized target out to its horizon-limited range of about 35 kilometers (see figure 11). Unless the Utkas can pop up out of ground effect to extend its radar horizon, it will require external sources of targeting information to exploit the 100-km effective range of its SS-N-22 missiles.

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Figure 9.



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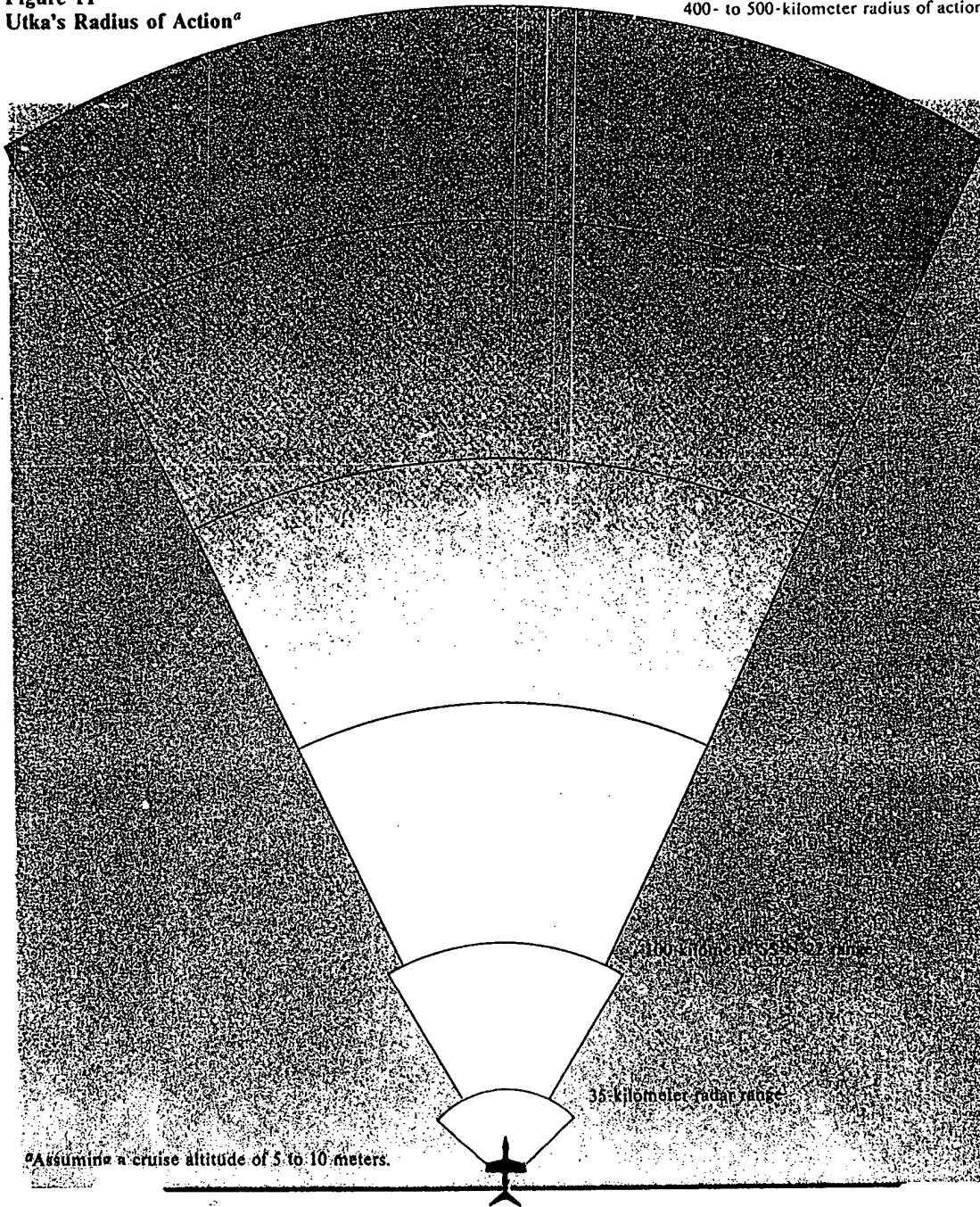
Figure 10.

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Figure 11
Utka's Radius of Action^a

400- to 500-kilometer radius of action

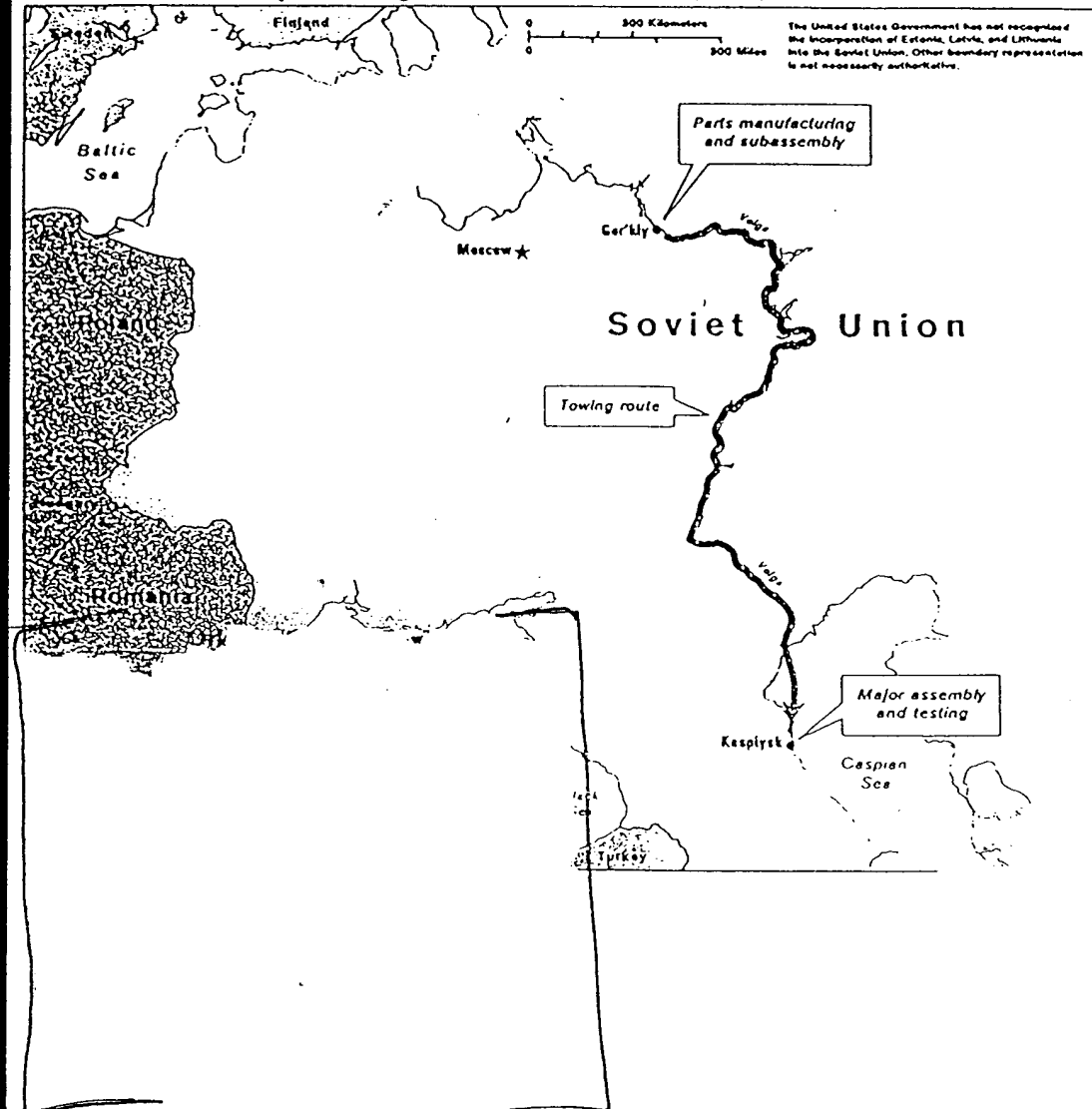


^aAssuming a cruise altitude of 5 to 10 meters.

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Figure 12
Manufacture and Transport of Wing-In-Ground-Effect Vehicles (WIGs)



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The effectiveness and survivability of the Utka will be limited against surface combatants that have airborne early warning and fighter aircraft protection.

(NIR) advanced the development of Orlan- and Utka-class WIGs. NIR is the procedure by which the Soviets cultivate new and emerging technologies. NIR is removed from actual weapons system development to promote exploratory research and to encourage aggressive testing free of military program deadlines and industrial resource commitments. When new technology is proved in NIR and demonstrated as producible, it is available for use in weapons system development (see figure 13).

The Soviet WIG Program: A Long-Term Commitment to System Procurement

The Orlan and Utka WIGs, like ships and submarines, are products of the Soviet Ministry of Shipbuilding Industry. They are designed by the Central Design Bureau for Hydrofoil Ships at the Krasnoye Sormovo Shipyard in Gor'kiy. The major subassemblies for these WIGs are produced at the shipyard and then transferred by river barge to the Caspian Sea for final assembly, fitting out, and sea trial.

Soviet directions in WIG research began to take shape in about 1962. Aerodynamic modeling and surface-effect studies on different WIG hulls were conducted during the early 1960s by aviation-related research centers and naval scientific research institutes. By 1964, the WIG project had moved into the final phase of NIR (applied research), where the most promising system concepts were developed and tested.

R. Ye. Alekseyev, chief designer at the Central Design Bureau for Hydrofoil Ships, designed piloted subscale WIGs and tested them at a public reservoir in Gor'kiy. They were assembled at the design bureau to demonstrate the feasibility of wing-in-ground effects in flying heavy cargo at high speeds, just above the water's surface.

More than 15 years of scientific research work and experimental design work were needed to produce the first WIG for the Soviet Navy. Much of that time was consumed in building and flying WIGs to gain a technology level sufficient to support weapons development.

Technology Base Buildup

We have learned by reconstructing the history of the Soviet WIG program that scientific research work

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[this test model—nicknamed the Caspi-
an Sea monster in the West—flew as a one-of-a-kind
full-scale, experimental research vehicle for at least
15 years before it crashed in the Caspian Sea some-
time between September 1980 and August 1981. This
WIG, first seen on satellite photography of September
1966, was built in Gor'kiy and transferred in pieces by
barge via the Volga River to the Caspian Sea. [

[it was
built solely to test subassemblies and components for
WIGs that were to be produced serially for the Soviet
Navy [

Weapons System Development

Sufficient progress in NIR testing had been achieved
by 1970 to permit Alekseyev to begin full-scale
engineering development of the Orlan and possibly
the Utka. This is the stage in Soviet weapons system
acquisition (called experimental design work, OKR)
when technology development is halted and system
development begins. [During OKR,
designs are finalized, contracts are let for component
production, and prototypes are assembled for testing
and production. Prototypes in the Ministry of Ship-
building Industry (unlike in the ministries for air and
ground forces) are considered lead units of new weap-
on system classes and are almost always deployed. [

Orlan Development. About four years were needed to
design and assemble the first Orlan-class WIG. [beginning about
1971, a series of tests was run on different WIG
model configurations at the Central Scientific Re-
search Institute of the Shipbuilding Industry. Soviet
shipbuilding acquisition standards dictate that all
preliminary designs generated in the draft design
phase of OKR be model tested by the institute. [

Orlan testing and production slowed considerably
after 1974 because of faulty components and subas-
semblies and pilot error. [

[an
Orlan—undoubtedly the lead unit assembled earlier
in Gor'kiy and barged to Kaspiysk in 1974—crashed
there. A second unit was assembled and delivered to
Kaspiysk [1977 for state acceptance tests
that [were postponed to a
later date because of technical problems. We believe
that those tests had been completed by 1981 because
third Orlan-class WIG had been built by then [

Utka Development. We are not sure when Utka's
technology development stopped and when its weap-
ons system development began. If the Utka entered
systems development with the Orlan in 1970 [we would have expected the Utka
to have been built sometime during the mid-to-late
1970s with technology comparable to that used in the
Orlan [

Normally about 10 to 12 years are needed to develop
new classes of naval weapons systems like the Utka.
But, if problems occur—like poor flight control sys-
tem performance and pilot error that prolonged Or-
lan-class testing in the early 1970s—more time is

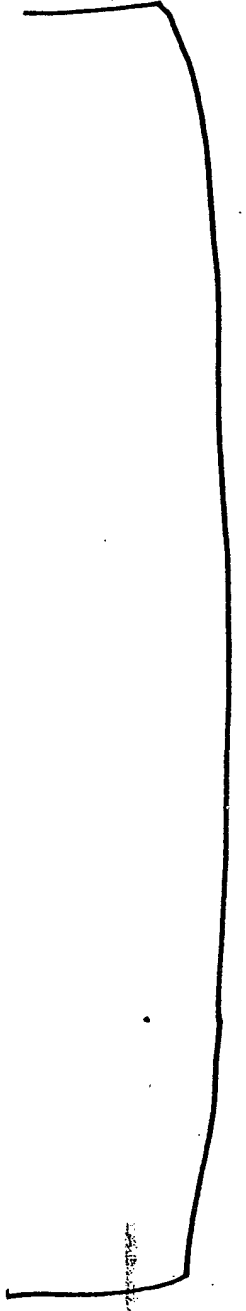
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Figure 13



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Outlook

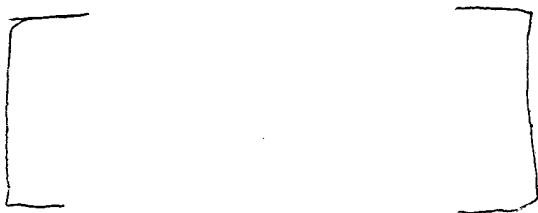
We believe that the Soviets intend to deploy the Orlan and the Utka to their Baltic, Northern, Pacific, and Black Sea Fleets. Initial deployment could begin in the early-to-mid-1990s. By the late 1990s, two or three Utkas and five or so Orlans could be assigned to each fleet. We expect the Black Sea and Baltic Fleets to receive more Orlans than the other fleets because their areas of operation are likely to include more amphibious assaults than the Pacific and Northern Fleets.

We are not sure how rapidly the Orlans and Utkas will be deployed to the four fleets. If WIG subassemblies are barged from Gor'kiy to the fleets for final assembly (as they are now to Kaspiysk for the Caspian Sea Flotilla), the Soviets probably intend to deploy only a few WIGs per year. We believe one Orlan and one Utka, or two to three units of the same WIG class, can be deployed in a year using this procedure. If higher numbers of WIGs are to be deployed, for example three WIGs in each class, the Soviets will probably need a facility larger than the one they use in Gor'kiy to produce the subassemblies. In addition, because of the unique nature of WIGs, special basing facilities—such as floating drydocks—would be required prior to the deployment of WIGs to the fleets.

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The Soviets may develop their WIGs as platforms for antisubmarine warfare (ASW) operations. WIGs can dash to an ASW prosecution area at 10 times the speed of conventional ASW ships and loiter for hours before moving quickly to another area. ASW-equipped WIGs would be likely to carry a variable depth sonar, a towed cable sonar array and depth charges, or ASW missiles and torpedoes.



In addition to coastal defense, amphibious assault operations, and ASW missions, Soviet WIGs could be used for other purposes. A minelaying WIG, for example, could be developed to carry and emplace sea mines. It would operate at several times the speed of conventional Soviet minelaying ships. WIGs could also be used as priority cargo carriers to build up stockpiles of equipment, ammunition, and fuel and as search and rescue platform:

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